21 EN ROUTE

The En Route system is the core of information flow throughout the NAS. Air route traffic control centers (ARTCCs) are critical information hubs for the NAS. Replacing the en route infrastructure is critical to sustaining NAS services, assuring safety, and meeting user demand. The ability to sustain day-to-day NAS services takes precedence over implementing new capabilities. However, at the same time that the hardware infrastructure is being replaced to address immediate needs, it is also necessary to begin software redesign to resolve the fundamental limitations of the existing software architecture to enable the modernization needed to support user demands for additional services.

The *Government/Industry Operational Concept for the Evolution of Free Flight* defines the future operations and services for controlling aircraft in the en route domain. The operational concept focuses on an increased ability to accommodate user preferences using decision support tools for air traffic control (conflict detection, conflict resolution, sequencing to terminal, and optimal descent patterns) and traffic flow management (collaborative decisionmaking, NAS flow analysis, and data exchange).

In support of this, the en route architecture features revised flight data management (FDM), continuous access to expanded flight information (e.g., position, velocity, intended trajectory, preferences, etc.), improved decision support tools, and improved surveillance processing with more accurate position, velocity, intent, and wind information. New procedures will be developed to take advantage of the new operational capabilities. The operational concept emphasizes that the NAS will evolve to accommodate a flexible airspace structure, including dynamic airspace boundary restrictions and dynamic sectors. The en route architecture provides a basis for achieving the functionality defined in the operational concept.

The en route architecture is driven by the near-term need to sustain and then replace the en route automation hardware systems (e.g., host computer system (Host), peripheral adapter module replacement item (PAMRI), and enhanced direct access radar channel (DARC)). The en route architecture evolution provides user benefits as early as possible in support of the operational concept and the Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) plans. FFP1 is discussed in Section 6, Free Flight Phase 1, Safe Flight 21, and Capstone.

21.1 En Route Architecture Evolution

The en route architecture seeks to sustain existing services while introducing new user services as early as practical. The first area of focus is the development of a stable hardware and systems software infrastructure with common operating systems and system services. New air traffic control (ATC) applications can then be put into place to enhance present en route capabilities.

Implementation of the en route architecture has been divided into four steps, beginning with the current operational prototypes and display upgrades and ending with enhancement and integration of the en route systems and decision support tools. An overview of the sequence and relationship of the en route functionality with respect to the en route architecture is shown in Figure 21-1. This figure and the figures for the en route architecture evolution steps show the initial operating capability (IOC) functionality. Before this deployment, extensive engineering development and integration is essential and must be funded to reduce the facilities and equipment (F&E) production procurement risks.

The first step includes replacing the Host hardware with Host/oceanic computer system replacement (HOCSR) to solve the end-of-service-life problems. It is important to note that currently, the software running on the HOSCR platform is essentially the same software architecture that was implemented in the early 1970s. The first step also includes completing the display system replacement (DSR) deployment, providing next-generation weather radar (NEXRAD) weather data to en route controllers, the prototyping efforts of center terminal radar approach control (TRACON) automation system/Traffic Management Advisor (CTAS/TMA), user request evaluation tool (URET), and the host interface device/NAS local area network (HID/NAS LAN).

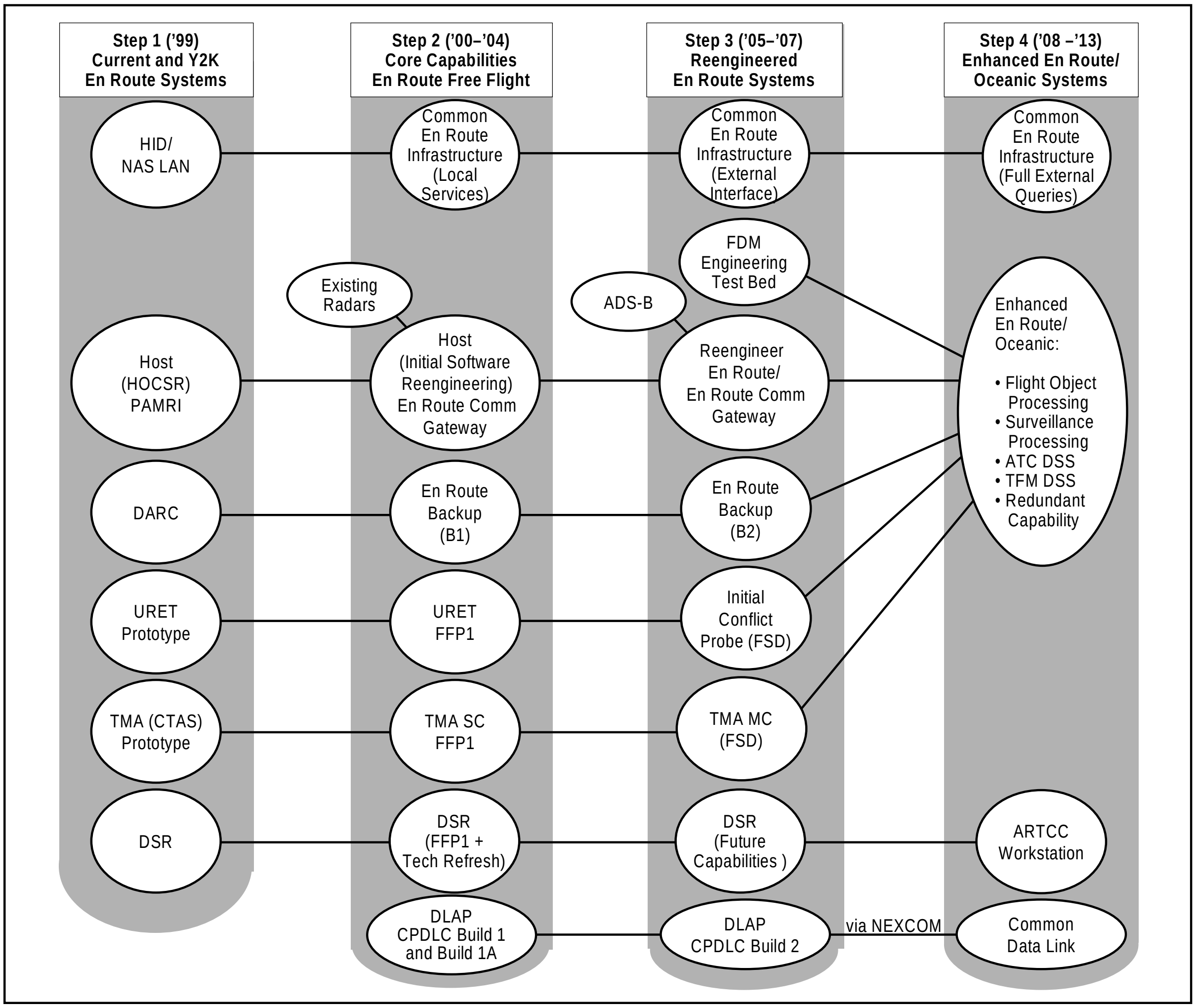

Figure 21-1. En Route Architecture Evolution

To introduce early functionality, en route capabilities will be expanded in the early stages with new applications executing on processors external to the Host/HOCSR—the first two of which will be the user request evaluation tool core capability limited deployment (URET CCLD) (evolved from the URET prototype) and TMA Single Center (SC) (evolved from the CTAS/TMA prototype).

In the second step, the en route FFP1 CCLD capabilities, (i.e., URET CCLD, TMA SC), along with controller-pilot data link communications (CPDLC) Builds 1 and 1A will be provided at selected ARTCCs. These functions are implemented on external processors and will be integrated into the core en route software architecture during the software reengineering in Steps 2 and 3. The integration will factor in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. URET CCLD implementation in FFP1 provides basic conflict probe capabilities to the en route center data-side (D-side) controllers[1] and will provide the capability for air traffic controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. Initially, conflict probe will be implemented on a Host outboard processor at selected domestic ARTCCs and will subsequently be integrated into the coordinated ATC decision support system (DSS) tool set. TMA will acquire

1. D-side controllers assist radar-side (R-side) controllers.

flight and track data from HOCSR and calculate schedules for arriving aircraft and send them to specific TRACONs with meter lists routed to en route controller workstations.

Also in the second step, DARC and PAMRI must be replaced due to their anticipated end of service life. These replacements, along with HOCSR technology refresh, will provide platforms to be used until the enhanced en route architecture is in place. At this time, the Host software reengineering effort will also begin with surveillance processing modifications to take advantage of improved accuracy and additional information available from existing sensors and avionics. Additional modifications to integrate oceanic and en route requirements will eventually lead to common en route/oceanic processing. The reengineered Host, the replaced DARC, and the replaced PAMRI (En Route Communications Gateway) will enable radar inputs from additional terminal radar sources, which can provide additional surveillance coverage.

The evolution to the en route infrastructure begins with the DSR LAN and HID/NAS LAN and eventually results in a communications structure (i.e., the common en route infrastructure) through which all new en route functions will interface. Flight information will eventually be available to all service providers and NAS users using information services and the en route infrastructure. These information exchange services will be common with the oceanic, terminal, tower, and support facilities as described in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

Concurrent with the en route functional evolution is implementation of an improved infrastructure, which is a combination of data standards, interface protocols, and a complementary suite of utility support for accessing/storing information, operating system interfacing, and translating between new and old data/interface formats. The infrastructure and services form the connectivity basis for the addition of new en route functionality into the ARTCC and for external access to ARTCC data.

Initial data link service will be introduced at one key site. Initial operational CPDLC service for non-time-critical applications will subsequently be made available nationwide. Prior to nationwide implementation, users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further deployment. Introduction of data link services will involve modifications to software and will require the addition of an outboard data link applications processor (DLAP).

During the third step, en route systems will be upgraded to accept automatic dependent surveillance (ADS) reports in addition to all of the existing sensor inputs. The position of aircraft in nonradar areas will be available to air traffic service providers through processed ADS reports. This higher level of accuracy in aircraft position and the downlinking of additional aircraft state data, such as velocity and intent, will permit enhancing decision support tools to increase system capacity and user-preferred route availability.

Step 3 will deliver aeronautical telecommunication network (ATN)-compliant CPDLC services. At each stage, these data link capabilities will be merged with new and existing ATC automation capabilities to take full advantage of the improved timeliness, reliability, and efficiency that data link services will bring to the ATC system. Eventually, the en route and oceanic data link communications and application software will be integrated into a common system.

As an expansion of the FFP1 tools, the reengineered en route system in Step 3 will contain an integrated version of conflict probe (CP) and multicenter metering with descent advisor. Part of the engineering analysis in Step 3 will be the flight data management test bed designed to prove the concept of a universal format for flight objects within en route, oceanic, and terminal domains.

In the fourth step of the en route architecture evolution, the existing functionalities that are provided by multiple systems will be replaced by an integrated en route/oceanic system developed in the previous two steps. The new concept of flight data management uses flight objects identified in the operational concept and provides electronic flight information for display to controllers. The ARTCC ATC DSS tool set is the collection, enhancement, and integration of conflict alert, conformance monitoring, conflict probe, and conflict resolution tools, which will be implemented and then enhanced.

The ARTCC ATC DSS functions support aircraft separation from other aircraft, hazardous weather, terrain obstructions, and restricted airspace. The combination of improved surveillance intent information, the tools in ARTCC ATC DSS, and the flight object in FDM will permit accommodation of user-preferred trajectories. Additionally, the ability to dynamically modify sector and center boundaries will be included to help balance controller workload.

The following sections present the en route architecture evolution in more detail. Architecture diagrams (Figures 21-2 through 21-5) show the content of each step in a logical or functional representation without any intention of implying a physical design or solution.

21.1.1 En Route Architecture Evolution—Step 1 (Current–1999)

In Step 1, the DSR program replaces the display channel complex replacements (DCCRs), computer display channels (CDCs), and plan view displays (PVDs). The HID/NAS LAN is also introduced (see Figure 21-2). Implementation of HID/NAS LAN forms a basis for adding new functionality and outboard processing (such as CP, TMA, and data link processing), allowing early delivery of new capabilities.

The Host is currently part of the primary channel ATC equipment used in the 20 domestic centers. It provides radar data processing (RDP) for center controllers and flight data processing services for center, terminal, and tower controllers.

DARC is a backup system that displays radar data and limited flight data to controllers when the primary system is down. DARC supports two modes of operation: NAS/DARC mode and DARC-only mode. In NAS/DARC mode, the Host is fully operational and provides the DARC with an interface to flight data. In DARC-only mode, flight data previously received from the Host cannot be updated, so the currentness of flight data degrades rapidly.

The Host flight data processor (FDP) defines the airspace boundaries and processes flight plans for aircraft that pass through each area, ensuring that proper routings are applied. FDP also prepares paper flight strips for the appropriate sector, terminal, and tower as the basis for coordination among adjacent NAS facilities. Flight strips are used to record information provided to an aircraft and for coordination activities.

PAMRI is an interface peripheral to the Host, providing the conduit through which the Host receives and exchanges data, primarily radar data and interfacility flight plan data.

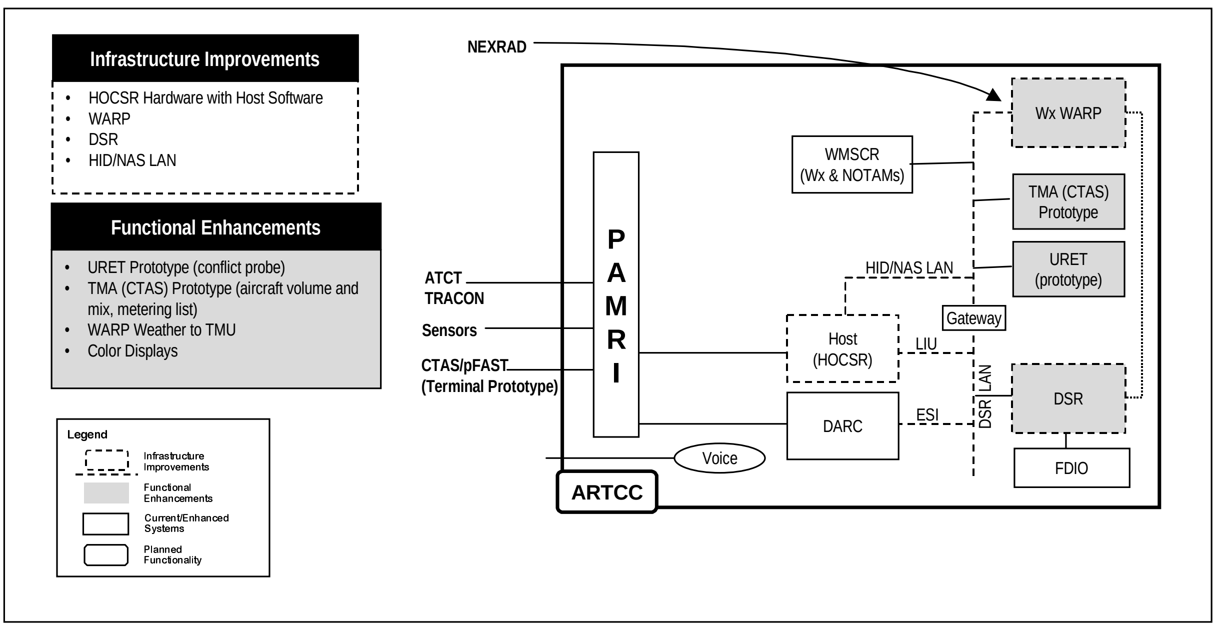

Figure 21-2. En Route Architecture Evolution—Step 1 (Current–1999)

The Host will be replaced in this step with a new platform, HOCSR, which uses the current application code with minimal modifications. Similar hardware replacement with HOCSR will be made for the oceanic display and planning system (ODAPS) (see Section 22, Oceanic and Offshore). This hardware replacement will solve the Host supportability problems.

At the Indianapolis ARTCC, a URET prototype is currently being evaluated for its ability to assist en route controllers in tactical planning to avoid potential downstream conflicts. A second URET prototype was installed in Memphis in 1997 to test conflict probes across center boundaries. Aided by forecast winds information, URET extracts real-time flight plan and tracking data from the Host, builds flight trajectories for all flights within or inbound to the center, and continuously checks for conflicts up to 20 minutes into the future. As the field trials progress, URET functionality is being displayed for use by the D-side controller. In subsequent steps, the URET CCLD FFP1 tool and full-scale development of CP will evolve from the URET prototype and the lessons learned in these field trials (see Steps 2 and 3).

The en route portion of the CTAS program includes a TMA tool for traffic managers and controllers in en route centers. This tool displays the volume and mix of aircraft destined for the entry points into the terminal area. CTAS/TMA provides miles-in-trail scheduling, time-based scheduling, and meter lists to controllers to ensure proper aircraft separation while increasing terminal capacity. This TMA function is a preproduction prototype installed at five high-capacity airports and associated ARTCCs.

HID/NAS LAN is a transitional infrastructure enhancement that will allow outboard processors for new applications to access the Host for data while minimizing use of the Host processor capacity to run the applications.

DSR provides color displays and will be delivered with new display interfaces to the Host/HOCSR. By the end of this period, DSR will display improved weather data from NEXRAD, which is processed by the weather and radar processor (WARP).

DARC, and PAMRI systems have reached the end of their service lives. Sustainment and replacement issues are discussed in the next step.

21.1.2 En Route Architecture Evolution—Step 2 (2000–2004)

In Step 2, PAMRI, and DARC functions will be sustained via replacement with modern platforms that can accommodate subsequent additions and modifications (see Figure 21-3).

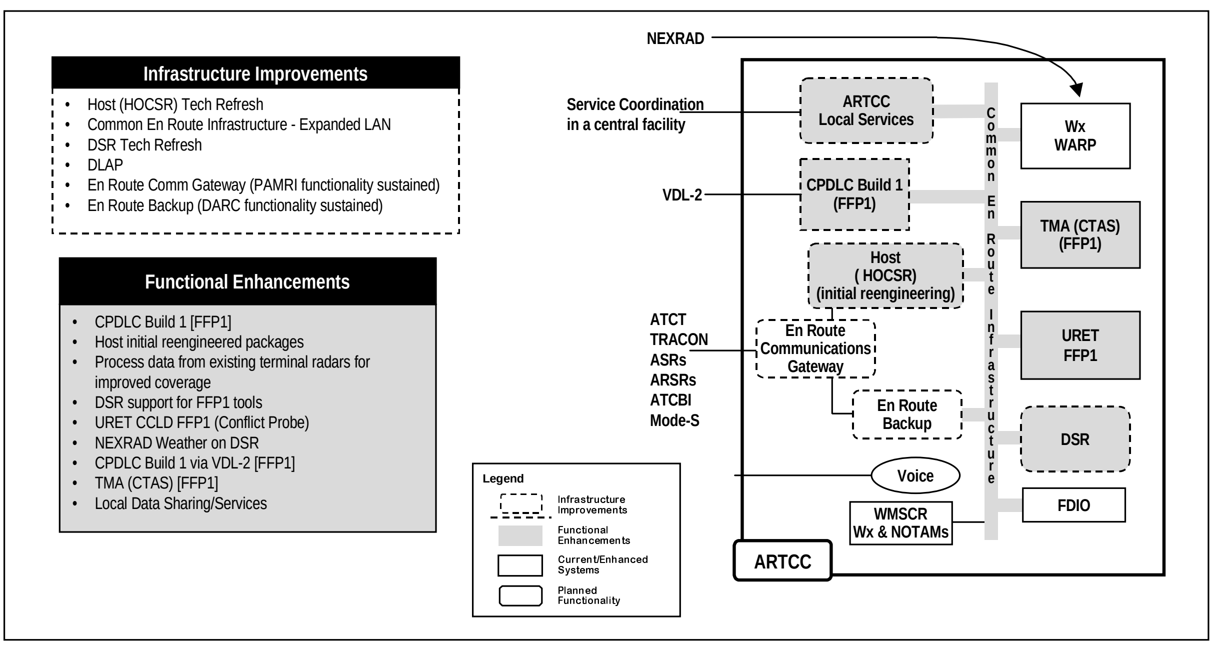

Figure 21-3. En Route Architecture Evolution—Step 2 (2000–2004)

Due to age and design characteristics, these current en route automation systems are limited in capacity and capability. They are also becoming unsupportable and limit operational flexibility within en route centers. The systems must be replaced with new systems that will support both current and future functionality and that can meet long-term availability, expandability, and efficiency requirements.

PAMRI will be replaced with the En Route Communications Gateway. It will be used in Steps 2 and 3 and will possibly be replaced for the enhanced en route/oceanic system described in Step 4. DARC will be replaced with a diverse (with respect to HOCSR) backup system, which will be used until Step 4, when a redundant capability will be incorporated in the enhanced en route/oceanic system.

URET CCLD is a limited deployment version of the functionality demonstrated in the URET prototypes and provides conflict probe core functions to selected sites identified for FFP1 CCLD capabilities. URET CCLD will use the DSR displays rather than outboard displays as in the prototype implementations. During Step 3, CP will undergo development and be deployed at all 20 domestic centers. Conflict probe functions will interface with HOCSR via HID/NAS LAN until its evolution to the common en route infrastructure.

The single center TMA tool will be implemented at selected sites for FFP1 CCLD, based on the TMA prototype described in Step 1. In future enhancements, TMA will include an improved descent advisory algorithm and time-based scheduling, and a multicenter TMA will be implemented in Step 3. Frequently, arrival streams to an airport have to be created, not only in a single en route center, but as a coordinated process with an adjacent en route center. By using aircraft track information across center boundaries, the trajectory can be modified earlier in the flight to minimize disruptions to traffic patterns while optimizing arrival rates.

Reengineering tasks will be performed to accommodate additional surveillance and communication sources and to initiate commonality with the oceanic domain. The HOCSR platform will provide the basis for developing common en route/oceanic processing. The surveillance processing in the En Route Communications Gateway and HOCSR will be reengineered to accept and process surveillance data from selected terminal radars. Additionally, these terminal sensors and many of the existing en route sensors can disseminate more accurate aircraft positional data to the automation system, as well as other valuable information that is presently not being utilized. This step will begin the process of redesigning the surveillance processing and other automation applications to make the best possible use of these sensor data. In this time frame, the complement of beacon sensors that will exist includes the monopulse ATC radar beacon system (ATCRBS) and Mode-S with ground-initiated downlink communications. It is anticipated that the addition of ADS coverage to this sensor mix will be accomplished in the next step. All terminal sensors will continue to have co-located primary radar surveillance.

The initial CPDLC Build 1 service for a limited message set, including transfer of communications (frequency change instruction), will be provided at one key site early in this step. CPDLC Build 1 is the first step toward achieving full CPDLC services. CPDLC will require software changes to the Host and DSR and the addition of an outboard DLAP. Users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safety before further development. If results are positive, the CPDLC tool will be fully deployed nationwide. Subsequently, the initial set of non-time-critical CPDLC service will be expanded (Build 1A). These services will use more of the International Civil Aviation Organization (ICAO) CPDLC message set. Subsequent CPDLC builds will require further modifications to Host software, DSR, and DLAP.

The FAA's ground system infrastructure necessary to support these capabilities will include DLAPs located at each ARTCC to support en route and oceanic data link services and at each TRACON to support terminal and tower data link services. Each DLAP will contain the communication protocols and applications required. Initially, DLAPs will connect to communications service provider networks and later to FAA-provided networks.

The common en route infrastructure requires standards and specifications and protocols to be followed. The en route infrastructure will evolve in parallel with the infrastructure evolution of the other FAA domains (terminal, oceanic, tower, flight service) and the Air Traffic Control System Command Center. This first increment of local services and the associated infrastructure enable all intrafacility systems to share information with each other and, in future steps, to provide the means by which each facility shares data with other FAA facilities and NAS users. To achieve this, the services and infrastructure will include standards and a set of utilities for communication, data storage and retrieval, data monitoring, and recording. During Step 2, platform security will be implemented for en route computers, and the HID/NAS LAN gateways will be augmented to control access from remote systems.

21.1.3 En Route Architecture Evolution—Step 3 (2005–2007)

Reengineering surveillance processing and decision support algorithms initiated in the previous step will continue on a larger scale. Step 3 (see Figure 21-4) involves introducing new surveillance inputs, modifications to the en route communications gateway and related computer hardware, and systems software and related air traffic control decision support software algorithms.

To achieve the en route performance goals, all sensor data (e.g., data from primary radars, beacon interrogators, and dependent surveillance) will be used to the maximum. Using the Mode-S downlink capability for additional aircraft state data and the later adding of automatic dependent surveillance broadcast (ADS-B) data will both improve coverage and add to aircraft positional accuracy. These sensor data will include real-time information on aircraft velocity (airspeed, heading, windspeed, direction), acceleration (bank angle, climb rate), and intent (assigned altitude, intended waypoints). A key surveillance processing improvement will be the ability of sensors to disseminate and automation systems to accept surveillance reports in the common surveillance message format. The All Purpose Structured EUROCONTROL Radar Information Exchange (ASTERIX) will provide the common surveillance message (described in Section 16, Surveillance).

Surveillance data processing (SDP) was developed to perform surveillance data fusion and reengineering of the decision support tools, which began in Step 2, and will be deployed to make maximum use of the additional data, accuracy,

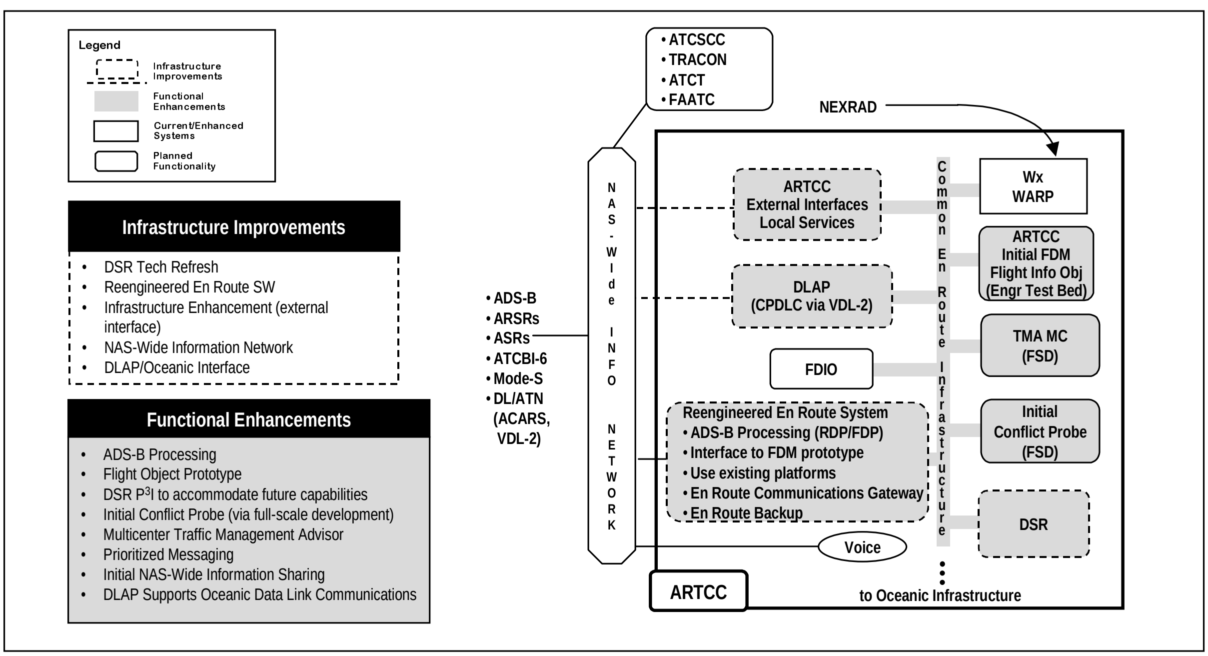

Figure 21-4. En Route Architecture Evolution–Reengineered En Route—Step 3 (2005–2007)

and update rates. These enhancements will permit increased traffic flow and allow more user preferred routes while enhancing safety.

Integrating the new data will require reengineering the en route communications gateway, the Host software, and related decision support algorithms. This is an evolutionary step leading to the en route architecture described in Step 4.

Developing and implementing a prototype FDM at selected sites is a risk-reduction strategy to verify use of flight objects and the display of additional data for ATC and user collaboration. This FDM prototype will be introduced into the en route, terminal, and oceanic domains, and it will be tested in shadow mode as an engineering test bed, in parallel with the operational FDP.

TMA SC will be expanded to include traffic management advisory capabilities across multiple en route centers (TMA Multicenter (MC)). This TMA expansion will also include improved descent advisory (DA) functionality by generating arrival clearance advisories as well as metering lists for TRACONs.

The URET CCLD FFP1 tool from Step 2 will be enhanced and deployed nationwide as CP. These enhancements will include improved computer-human interface (CHI), integration into the radar position (R-side), and other improvements.

Cutover to the next-generation air-ground communications system (NEXCOM) very high frequency digital link (VDL) Mode-3 voice operation is planned to take place in the high- and super high-altitude en route sectors.

The CPDLC message set will be expanded to approximately 100 messages (Build 2). DSR modifications will enable the en route system to display CPDLC information and new ADS-B data.

With development of the initial NAS-wide information network and common data services, applications will be able to send and receive en route information through local information exchange. This capability includes connectivity between FAA facilities as well as with NAS users through information sharing.

21.1.4 En Route Architecture Evolution—Step 4 (2008–2015)

In this step, the en route systems evolve toward a common hardware and software structure with the oceanic systems, although some applications may remain unique in each domain. The enhanced en route architecture (see Figure 21-5) implements FDM and advanced ARTCC ATC DSS tools. The need for a standard interface with NAS users drives implementation of the domain infrastructures and the local and NAS services.

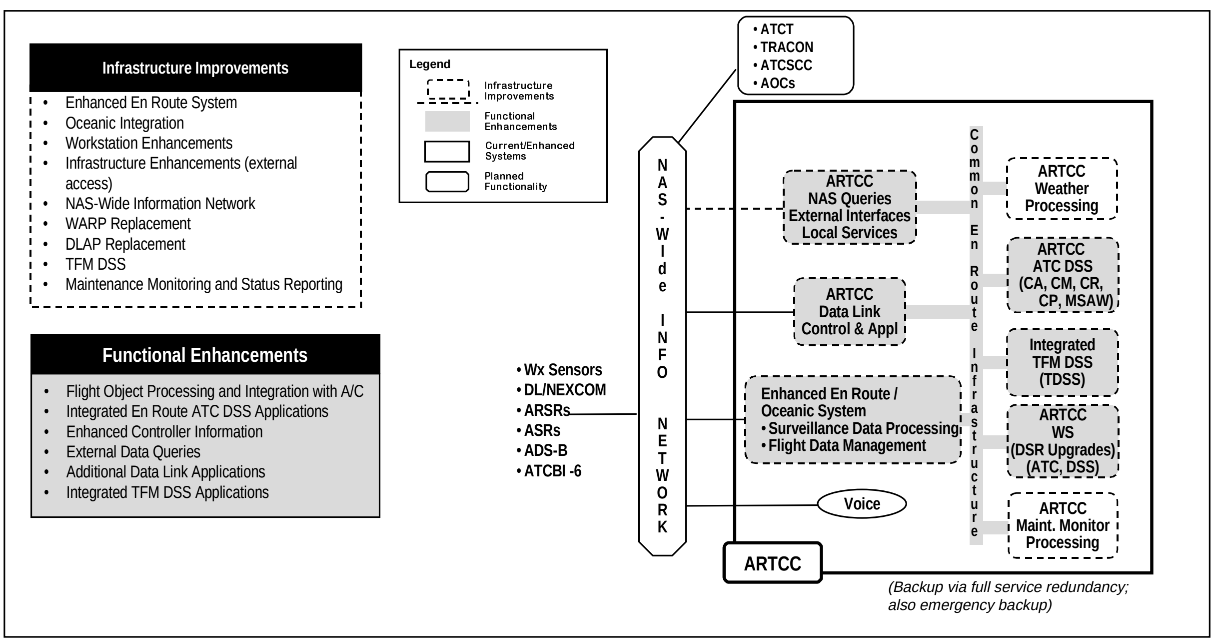

Figure 21-5. En Route Architecture Evolution–Enhanced En Route—Step 4 (2008–2015)

Surveillance processing will receive input from available sensors (e.g., primary radars, beacon interrogators, dependent surveillance), determine the position to be used for aircraft covered by multiple sensors, and provide the data (position, velocity, intent, etc.) for display and use by other DSS applications.

The replacement of FDP by FDM is driven by the operational concept approach of creating a flight object that increases the information within the flight plan and facilitates sharing of this information across domain boundaries with all authorized NAS users. In addition to expanding FDP functions in ARTCCs, the new FDM supports collaborative use at additional FAA and user facilities. The flight object contains all information about a flight (from the planning stage to the postflight archiving and analysis stages).

With FDM, flight plan processing and approval will be done nationally. Since the en route architecture is a logical architecture, the physical implementation of FDM is not implied. FDM will be implemented in a manner to prevent bottlenecks and loss of capability should one or more facilities be temporarily out of service. Each FAA air traffic facility will be capable of operating autonomously if necessary. Alternate facilities will assume FDM responsibilities in the event of an outage.

When a flight plan is activated, the flight object is retrieved and passed to the FAA ATC facilities responsible for that flight. As the flight progresses, the flight object data are automatically updated by the FDM at the controlling facility, and periodic updates are available through the NAS-wide information services for access by other FAA facilities or NAS users. FDM will archive the flight object during the flight and will maintain a permanent flight history. The content of the flight object is described further in Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing.

The availability of improved aircraft position, velocity, intent, and wind information and the implementation of new automated decision support tools will assist controllers in separating aircraft from restricted airspace, hazardous weather, and other aircraft. It will also allow more user-preferred routes to be granted.

Full ATN-compliant CPDLC services (Build 3), including air-ground automation data exchange, will be delivered via NEXCOM. Introducing data link services will require modifications to the Host software, DSR, and DLAP. Data link via NEXCOM will provide time-critical data communications for ATC and will support collaborative planning such as user-preferred trajectories. CPDLC will support selective authentication of safety-critical messages.

Modifications to the content of and interfaces to controller displays will be required to accommodate the new integrated capabilities and flight object data. The following ARTCC ATC decision support tools will be integrated onto common platforms and the required reliability and accuracy will be maintained or improved:

- Conflict Alert
- Minimum Safe Altitude Warning
- Conflict Probe
- Weather processing interfaces to the air traffic control decision support system (ADSS)
- Conflict Resolution
- Descent Advisor
- Conformance Monitoring
- Multicenter Metering.

Additional tools will assist controllers in maintaining situational awareness and monitoring the status of airspace configuration (e.g., restricted airspace, hazardous weather location, sector boundaries). Data exchange capabilities will give service providers and NAS users an informed basis for collaboration on trajectory and strategic airspace solution planning.

Traffic flow managers and controllers will have access to the same decision tools and flight objects. These tools, with adjustments to the parameters (e.g., look-ahead time), will become density tools for assessing the ripple effect of airspace changes. Modified trajectories can be developed collaboratively with airline operation centers (AOCs), pilots, and other NAS users. The new trajectories can then be distributed to flight decks and downstream facilities. Traffic flow managers will have access to common ATM workstations as part of the TFM DSS.

Dynamic resectorization is an advanced concept that will allow ATC facilities to configure airspace boundaries in real time to accommodate varying traffic flows. ATC personnel will be able to coordinate minor sector boundary changes among themselves to reduce manual coordination and make their assigned airspace more efficient for existing traffic flow. These advanced concepts, which incorporate multiple center and sector reconfiguration capabilities, require further study to determine their feasibility.

In support of the en route enhancements, the infrastructure will provide these additional capabilities:

- Infrastructure and processing between en route and oceanic domains (New York, Oakland, and Anchorage) will be common.
- Local information service will accept and process queries from NAS users.
- Data link applications will enable common domestic and oceanic data link services.
- Automated monitoring and status reporting interfaces with NAS infrastructure management system.

The enhanced en route/oceanic architecture (see Figure 21-6) provides full ATC functionality for two physically separate, redundant systems. Each full-service system will perform all functions, interface with controller workstations, and receive data from all external systems.

An en route investment analysis will determine whether a tertiary backup system is needed to cover situations in which the primary and secondary systems both fail or are not available for some unpredictable reason. This analysis will also cover the safety implications of the various possible configurations and the impact of such issues as rapid cold start, warm start, recovery times, maintenance actions, and common-mode failures. Figure 21-6 shows a possible backup system with hardware and software diversity.

21.2 Summary of Capabilities

A stable hardware and systems software infrastructure with common operating systems and system services will be available at each step in the evolutionary system as a platform upon which ATC applications can be developed.

Initially, the en route FFP1 CCLD capabilities (URET CCLD and TMA SC), will be provided at selected ARTCCs. These functions are implemented on outboard processors, and will be subsequently integrated into the core en route software architecture during the reengineering of the host software. The integration will involve factoring in lessons learned from the prototype implementations in FFP1 activities and the efforts necessary to make these products suitable for national deployment. Figure 21-7 summarizes the capabilities evolution.

URET CCLD will allow controllers to accurately predict aircraft trajectories 20 minutes ahead and identify potential conflicts. URET CCLD will evolve to CP and be deployed nationwide. CP will be integrated into the en route automation, al-

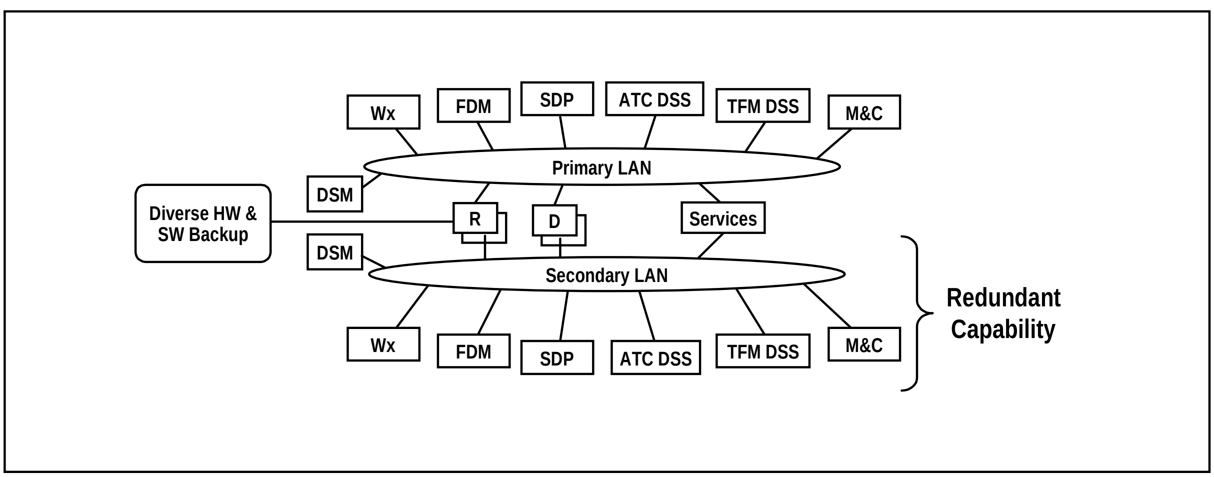

Figure 21-6. Redundant Functionality in En Route Architecture

lowing controllers to grant additional user-preferred routing.

TMA will assist controllers by calculating arrival schedules for sequencing to terminal facilities. The increased situational awareness will allow controllers to grant more user requests. TMA, which was initially deployed as a single center capability, will evolve to incorporate a multicenter capability allowing metering of aircraft to terminal areas across ARTCC boundaries.

CPDLC Build 1 will be initially installed at a single center so that controllers and pilots can gain operational experience with this capability. Subsequent national deployments will provide expanded operational information exchange by incorporating additional messages. Data link will provide additional interfaces for decision support tools as they evolve.

Implementing the flight object and the NAS-wide information services will allow data sharing across domains, facilities, and NAS users. This sharing will benefit users by enhancing the airlines planning to support daily operations. It will also improve the effectiveness of the ARTCC ATC decision support tools that provide both safety and efficiency benefits to all users.

En route automation will receive more accurate aircraft position, velocity, and intent information from both the Mode-S downlink and the ADS systems. ADS-B receives very accurate position determination from the Global Positioning System (GPS) and broadcasts aircraft information to other aircraft and ground facilities. This improved information used by enhanced DSS tools will improve en route system capacity and efficiency and may allow reduced separation standards to be implemented. Dynamic resectorization, to balance controller workload and potentially increase capacity, is a longer-term goal.

21.3 Human Factors

Implementing new hardware and software in DSSs, implementing new applications, and enabling en route technologies entails significant improvements in the way en route controllers conduct operations and provide traffic management services. Through an acquisition process that entails close collaboration with users, the resulting enhancements will provide new and different Air Traffic Service (AAT) and Airway Facilities Service (AAF) workforce tools, skills, procedures, and training. Some of the more significant increases to human-system performance include those related to:

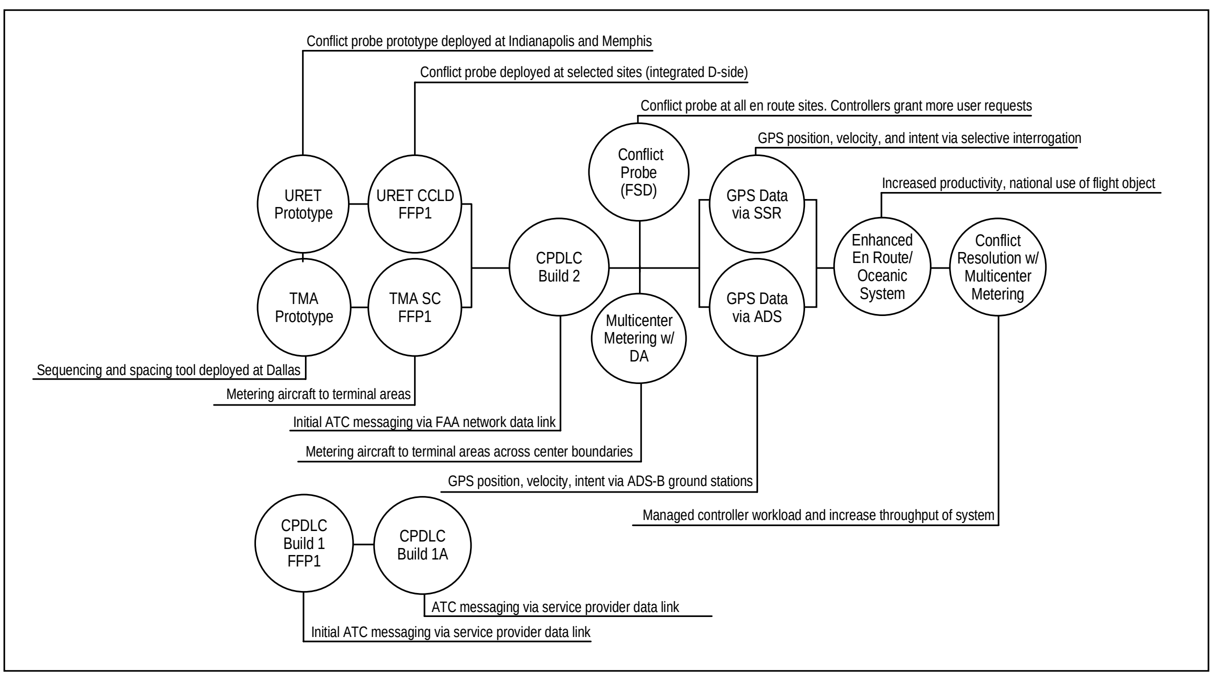

Figure 21-7. En Route Capabilities Summary

- **Information Dissemination:** Devising methods of distributing information among cooperative and collaborative en route decision-makers for such services as:
  - Advisories that inform ground and aircraft crews about alert/protected zone conditions, warnings, and resolutions
  - Common views and warnings of terrain, special use airspace (SUA), obstructions, and weather
  - Real-time reporting to users and service providers of radar, beacon, ADS, and other position information
  - Increased availability and updating of pilot intent and aircraft performance data
  - Information on integrity and timeliness needed to support flight object and DSS implementation.
- **Prototype Implementation:** Conducting the transition of prototypes for production and implementation such as:
  - Ensuring new functionality and/or CHI associated with individual prototypes or enhancements is effective and compatible (for operational/supportability) when integrated to form an evolutionary target en route baseline
  - Designing target workstations for the addition of new functionality (e.g., adequacy of the DSR data position (D-side) monitor for a conflict probe, availability of function keys on R-side, D-side, and monitoring and control (M&C) keyboards)
  - Clarifying the roles and responsibilities for new ATC applications (e.g., where DSR consoles are to be used for TMU positions).
- **Workstation Design:** Eliminating individual controller and maintenance workstation designs, divergent CHI, or incompatible CHI—especially where commercial software and application systems are prototyped and defined as independent systems that later interconnect to the Host via the HID/NAS LAN or are integrated into a single position or sector.
- **Failure Mode:** Designing (human) error-tolerant failure mode procedures, systems, and operations (under degraded or outage conditions) where there is heavy reliance on automated decision support tools for maintaining separation standards and tactical situational awareness.
- **Training and Transition:** Assessing training implications and transition requirements resulting from incremental implementation of new air traffic and airways facilities features and functionality and ATC functionalities that require significant use of common “display real estate” (e.g., tradeoffs between size of D-side glass and strip capacity).
- **Analyses:** Conducting en route analyses in support of:
  - DSR upgrades for enhanced color coding, operational display and input development (ODID) style graphical user interface, and revised CHI standard for R-side, D-side, and M&C positions
  - Baselining ARTCC en route operational and support work environments for additions to a configuration-management-controlled en route baseline
  - Design and development of a new and integrated ARTCC inventory of visual and aural alerts and alarms
  - Human factors investment analysis for the Host/DARC replacement and for en route conflict probe
  - Implementation of CHI design attribute allocation and configuration control systems.
- **Performance Measures:** Establishing objective en route measures for integrated human-system performance for such major milestones as successful completion of operational test and evaluation, initial operating capability, and operational readiness demonstration.

21.4 Transition

Figure 21-8 summarizes the en route activities transition.

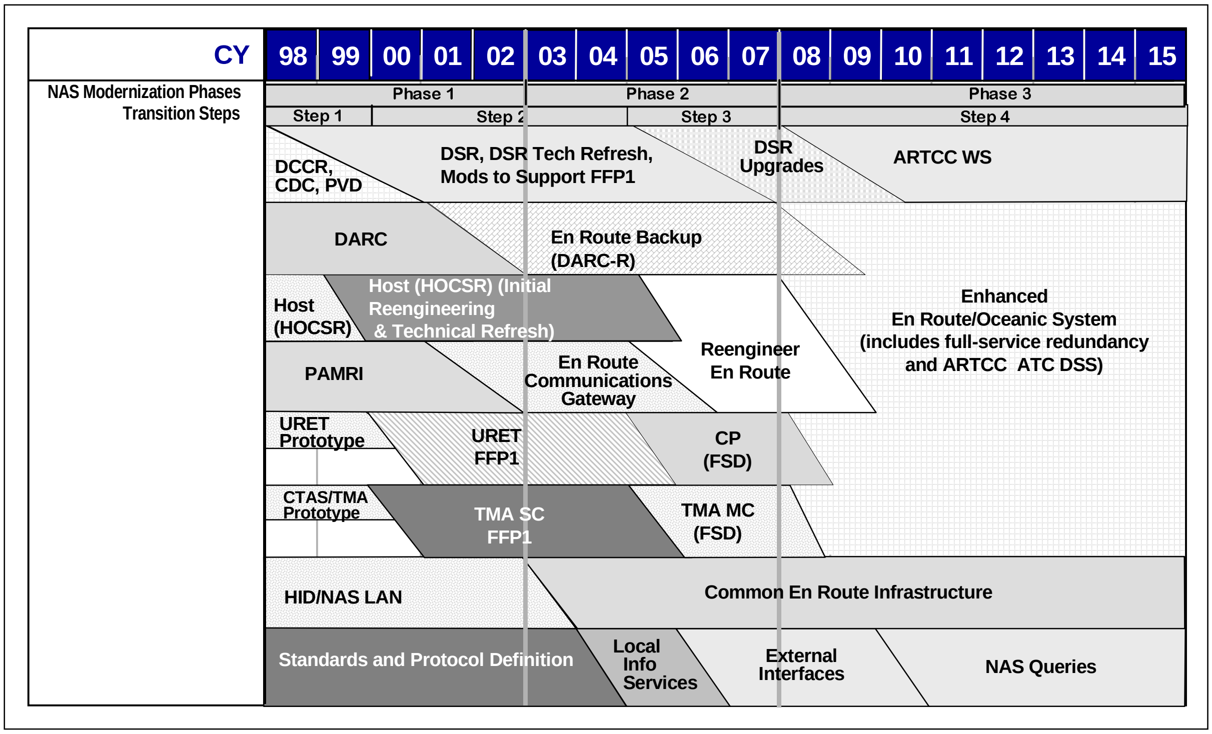

Figure 21-8. En Route Transition

21.5 Costs

The FAA's estimated costs for research, engineering, and development (R,E&D); F&E); and operations (OPS) are shown in constant FY98 dollars in Figure 21-9.

21.6 Watch Items

Achieving the en route functionality and operational benefits within the schedules and budgets described in the architecture depends upon the funding and success of the following related activities.

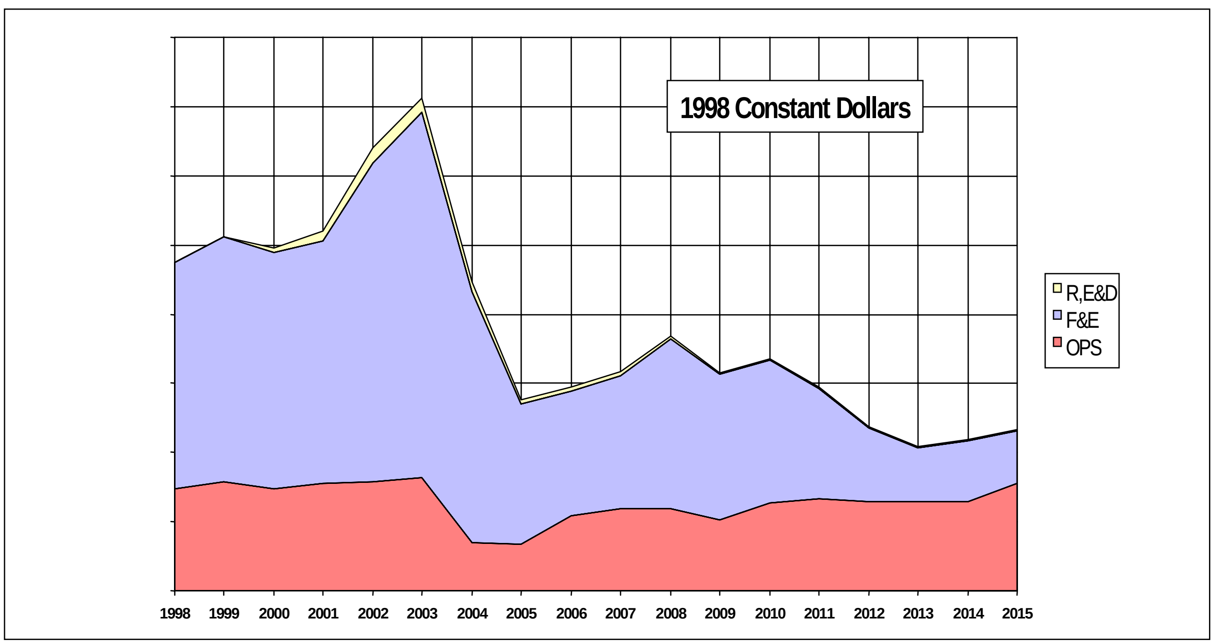

Figure 21-9. Estimated En Route Automation Costs

PART III

- Demonstrating the ability of ground automation systems to process improved surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS; to merge these data with radar data; and to display this information to controllers with an acceptable CHI. Results of these demonstrations would include processing algorithms and CHI standards that could then be incorporated into the en route core functionality between 2005 and 2008
- Timely deployment of the Host, DARC, and PAMRI hardware supportability solutions that solve the infrastructure replacement problems in the near term and provide a bridge to the new capabilities of the reengineered en route system
- Success of the FFP1 prototypes for the en route domain (URET and TMA SC) and conversion to production programs for initial conflict probe and TMA
- Transitional airspace structures and airspace redesign and their effect upon the labor-intensive effort necessary for site adaptation data maintenance. These affect both the current systems and the new decision support tools.

The budget for incorporating some of the future functionality is related to developing common algorithms to provide this functionality across domains where appropriate. Areas where common functionality across domains is anticipated are:

- Common surveillance processing and ADS data fusion in the terminal, en route, and surface domains
- Incorporation of more accurate surveillance, intent, aircraft state, and wind data from both Mode-S downlink and ADS to improve decision support tools
- Common weather services
- Common flight object processing
- Common functionality in some ATC DSS and safety-related tools.